

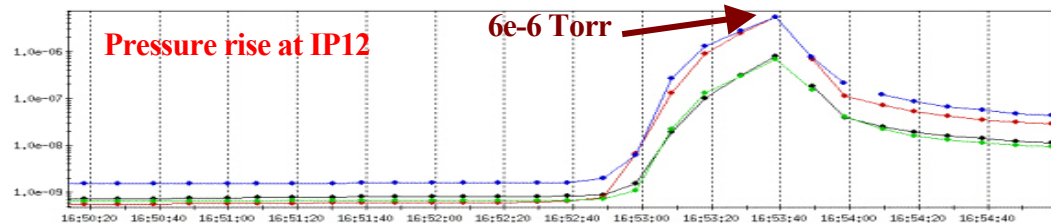
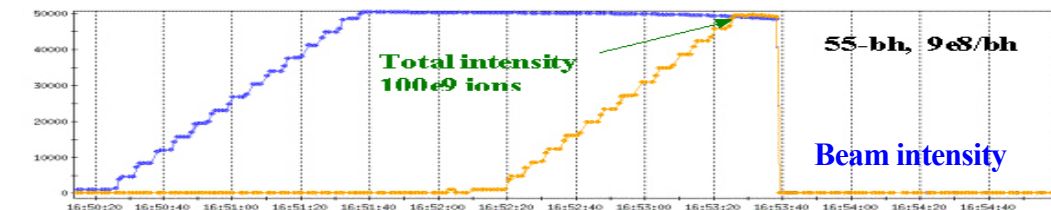
# RHIC Pressure Rise and Electron Cloud

S.Y. Zhang, RHIC Beam Experiments Workshop, September 26-27, 2002

## I. Pressure rise observations

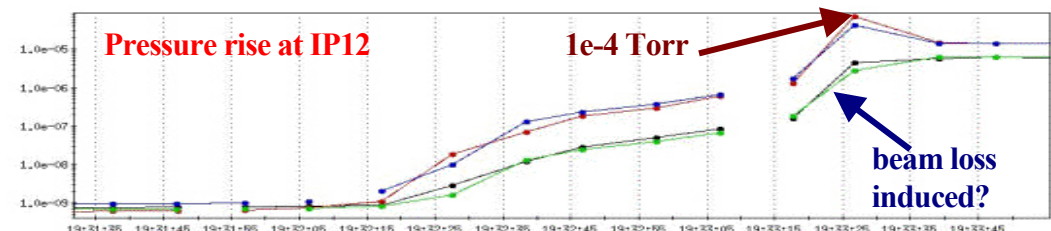
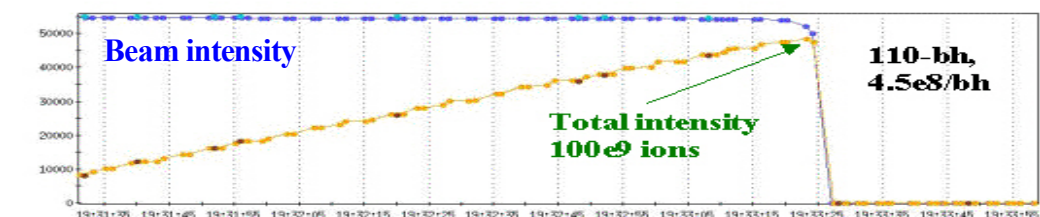
### 1. Gold beam 55-bunch

- Gold beam injection at  $9e8$  ions / bunch, pressure rises to  $6e-6$  Torr at IP 12, vacuum valve closed.
- Bunch intensity was 90% of the design.



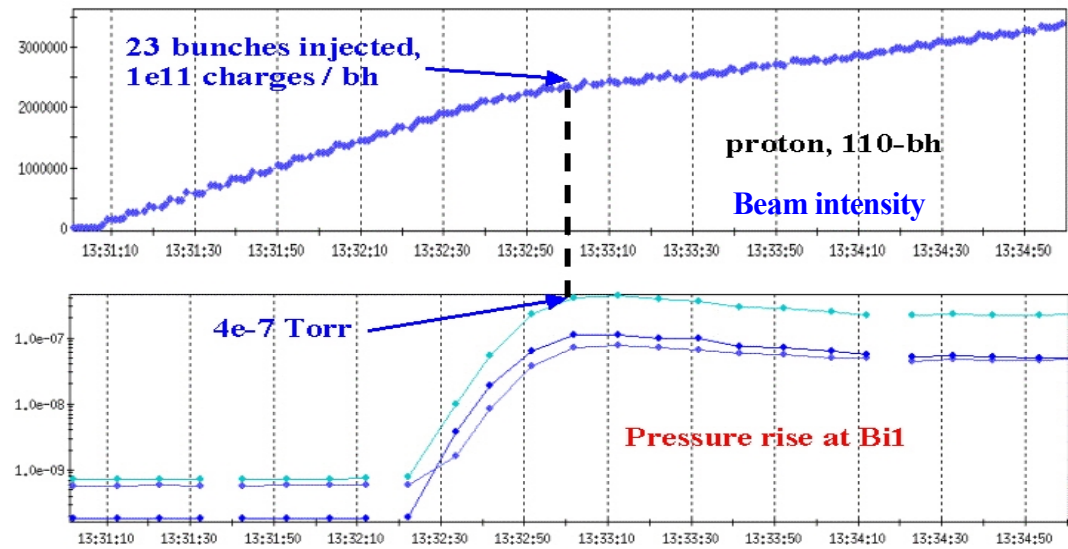
### 2. Gold beam 110-bunch

- Gold beam injection at  $4.5e8$  ions / bunch, pressure rises to  $1e-4$  Torr at IP 12, valve closed.
- Two types of pressure rise. Electron multipacting and beam loss?



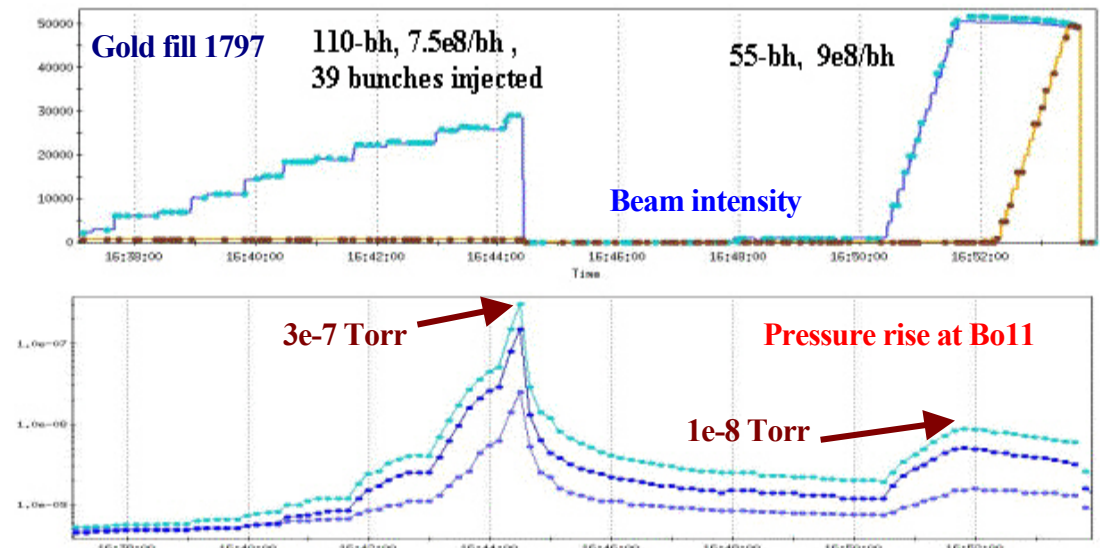
### 3. Proton 110-bunch

- Bunch intensity  $1e11$ , as 23 bhs injected, pressure rises to  $4e-7$  Torr at Bi1.
- Injection become bad after 23 bunches, probably because of the inj. kicker.
- Possible intensity limitation in proton 110-bunch?



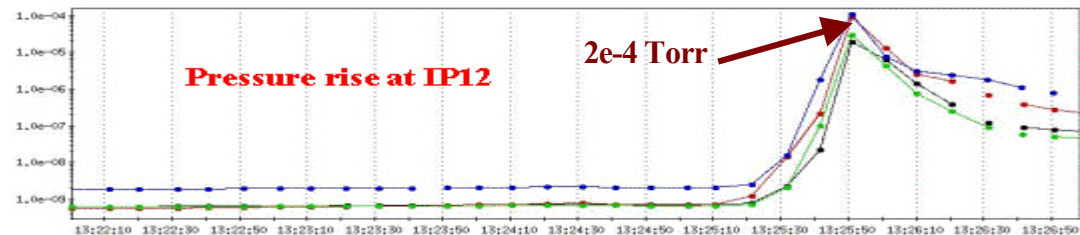
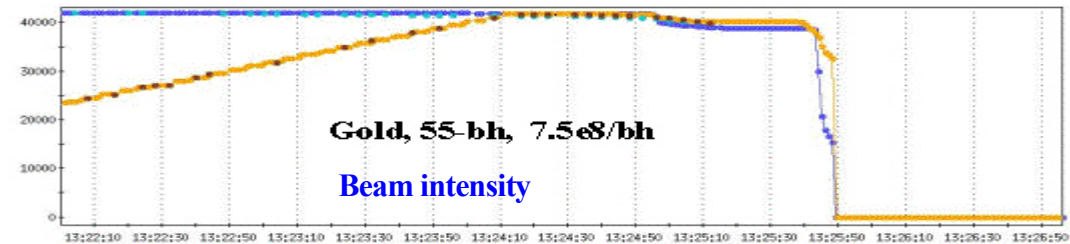
### 4. Electron cloud?

- 110-bh,  $7.5e8$  ions/bh, total intensity of  $3e10$  ions : pressure rises to  $3e-7$  Torr.
- 55-bh,  $9e8$  ions/bh, total intensity of  $5e10$  ions: pressure rises to  $1e-8$  Torr.
- Pressure rise is more sensitive to **bunch spacing** than the total intensity.



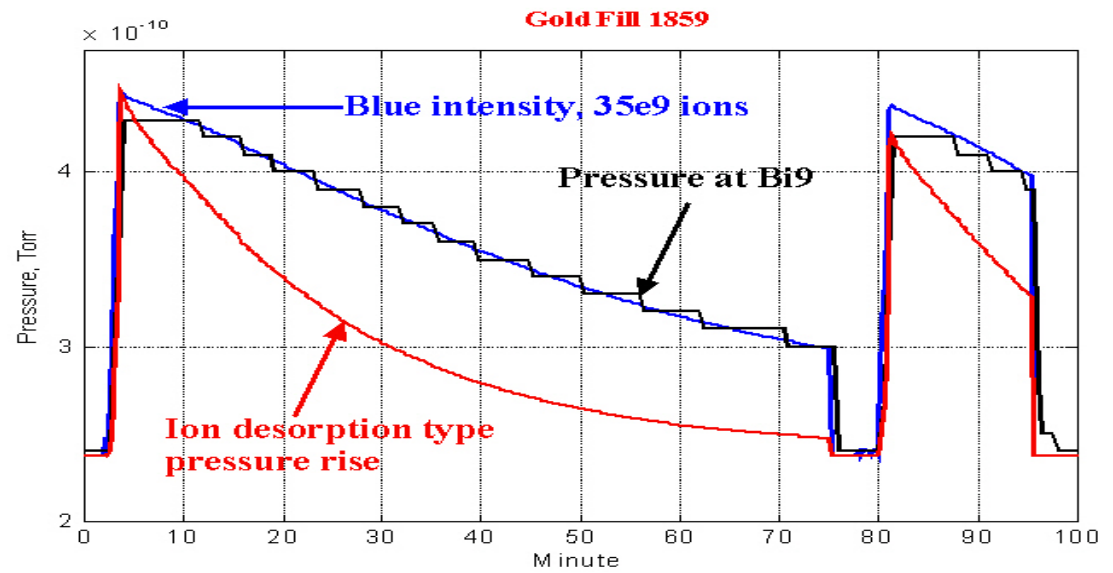
## 5. Beam loss effect

- Gold beam loss induced pressure rise to  $2e-4$  Torr.
- Pressure run away type, which is different from the electron multipacting induced pressure rise.
- Each lost gold ion desorbed  $>15e6$  molecules.



## 6. Ion desorption?

- The low pressure rise is linearly proportional to the beam intensity.
- Large discrepancy with the ion-desorption type pressure rise (ISR).
- Halo scraping?



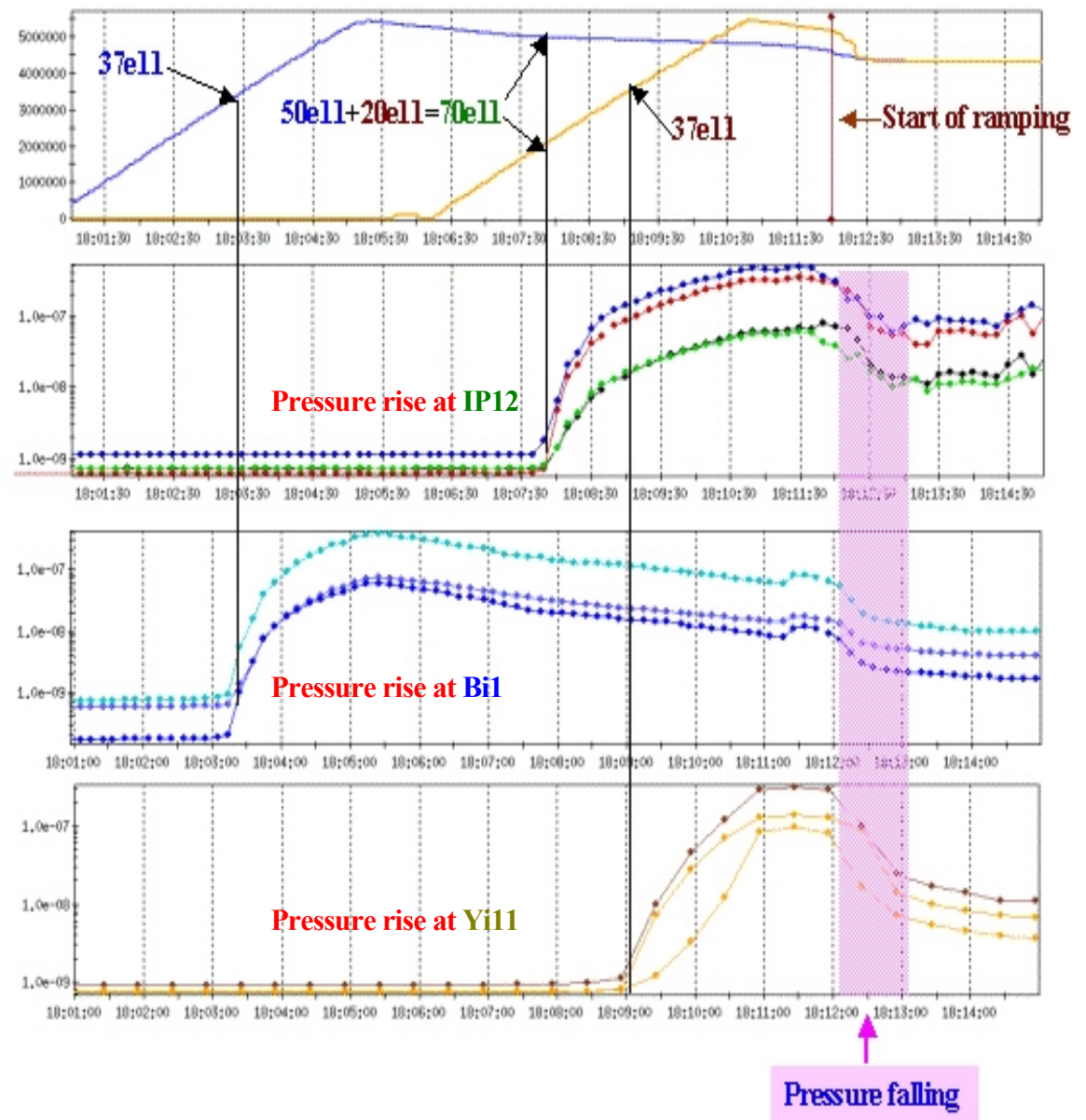
## 7. EC threshold

- Both beam 1e11 / bh.
- At 60 meter long single beam straight sections, the EC threshold is **37e11**. At a 25 meter long interaction region, it is **70e11**.

- Chambers are similar, only lengths are different.
- Halo scraping on the wall, which is worse for longer straights?

## 8. Pressure rise reduced at the ramp

- Because of the ions leaked from RF bucket?
- But why the pressure rise was very unevenly distributed in the ring?
- Because beam size reduces at the ramp?





## II. Study preparation

### 1. Two study stations

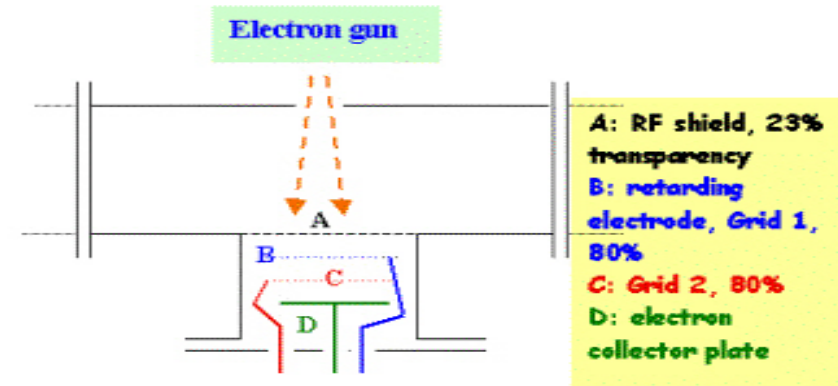
- One at the interaction region IR12, and another at the blue beam long straight section at sector 1 (Bi1).
- Each station is equipped with,
  1. A horizontal and a vertical electron detector, each with two grids. Grid 1 and collector with  $\pm 1$  kV bias adjustable, grid 2 will have -10 V bias.
  2. Three vacuum gauges located near center and near both ends of straight section.
  3. Solenoid with at least 8 meters coverage around detectors. Field is adjustable, and highest field is about 70 Gauss.
  4. Eight pin-diodes around the chamber, near detectors, which will be used to detect the beam loss in the vicinity, with very high sensitivity.
  5. A residual gas analyzer, RGA.
  6. An electron multiplier.
  7. A BPM type pick-up at Bi1, to collect electrons for comparison.

### 2. Control and software

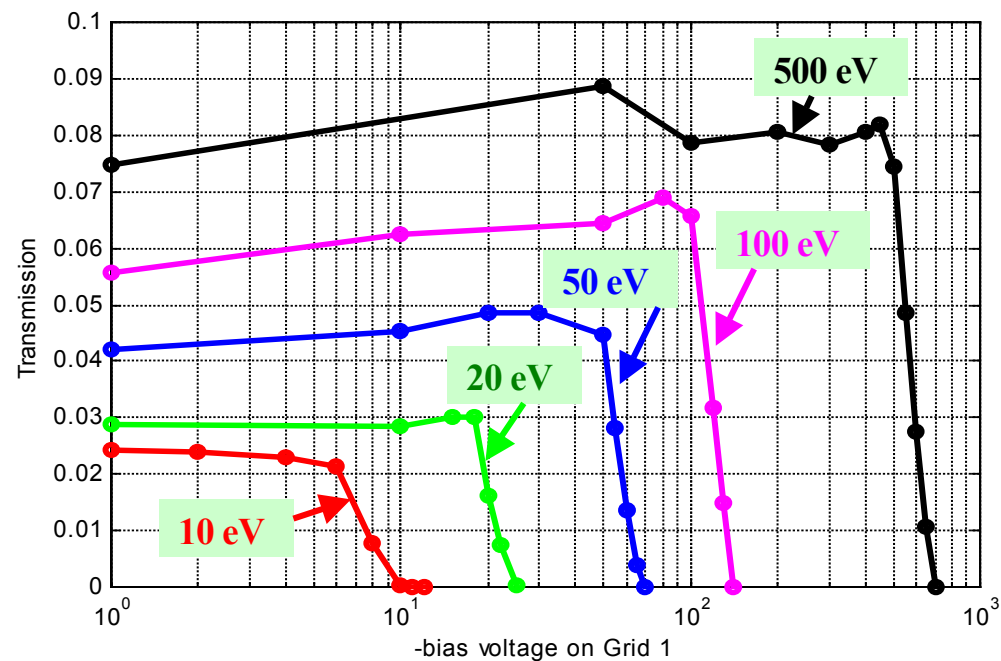
- Pressure rise over the ring will be monitored in a waterfall display.
- Electron cloud will be monitored in two modes
  1. Slow mode comparable with the pressure rise monitoring, 1 second resolution.
  2. Fast mode through scopes with resolution of 10 ns.

### 3. Electron detector test

- Low energy electron detection is affected by:
  1. Secondary electrons, which have energy around 3eV.
  2. Backscattered electrons, which have a little lower energy than primary ones. Backscattering rate is highest for primaries with the energy  $\leq 20$  eV.
- May be improved by small negative bias on grid 2 (Faraday cup alike).
- With -10 V bias on grid 2, the low energy electrons are well detected.
- The transmission rate can be used for calibration.



ED measurement at Building 820



### **III. Study plan - looking for solutions**

#### **1. Electron cloud and pressure rise**

Time structure and the electron density can show if EC is the main cause of the pressure rise. Electron density is not a settled issue in the EC study.

#### **2. Solenoid effect**

Possible solution? If we decide to use it, then need to specify parameters.

#### **3. Electron cloud vs. beam injection pattern**

Another possible solution? Lots of information may come out of this study.

#### **4. Beam scrubbing**

Could be a major effort to achieve the 2003 intensity goal (solenoid covered only 65 meters ). Thomas Roser has asked to make a 'commissioning plan'.

#### **5. Gap cleaning at the injection**

Ions leaked out of the bucket may help e-multipacting, and then disappear at the ramp. This study is relevant to the discussion of the AC-DC issue in ECLOUD'02. We are also interested in possible EC threshold increase by gap cleaning.

#### **6. Beam halo scraping and beam loss effect**

- (1) May help to answer some questions for the RHIC, e.g., why single beam straight section has lower EC threshold? why EC takes place for 216 ns bunch spacing in the RHIC? is that because of halo scraping, or beam loss?
- (2) Given the EC problem solved, we still worry about heavy ion beam loss.

**7. RHIC electron cloud and vacuum pressure rise characteristics**

A complete knowledge is crucial in understanding the RHIC problem. These include electron energy, density, gas composition, and their evolution. RHIC electron detector may also be used to detect ions.

**8. Coherent tune shift along the bunch injection**

We had successful measurements last run, but still a lot to do. This study will also help in estimating the electron cloud density in the RHIC.

**9. EC incoherent tune spread vs. beam-beam, octupole, and chromaticity**

EC will harm the beam stability from both coherent and incoherent aspects. The coherent factor is better understood, but not for the incoherent one. In the last run, beam-beam collision and later octupole were used to stabilize the beam in the RHIC, presumably due to the enhanced incoherent tune spread.

**10. Secondary electron and ion glancing angle production using collimator**

This is relevant to the RHIC, but no such experiment at the high energy of the RHIC has been performed.

**11. ATR (AGS to RHIC transfer line) vacuum study by steering beam**

To help understanding the pressure rise at the long straight sections.

Thanks for many helpful suggestions and discussions from in- and out-lab. The discussion is still going on, and the comments are very welcome!



## IV. Beam scrubbing - preliminary commissioning plan

### 1. A brief history

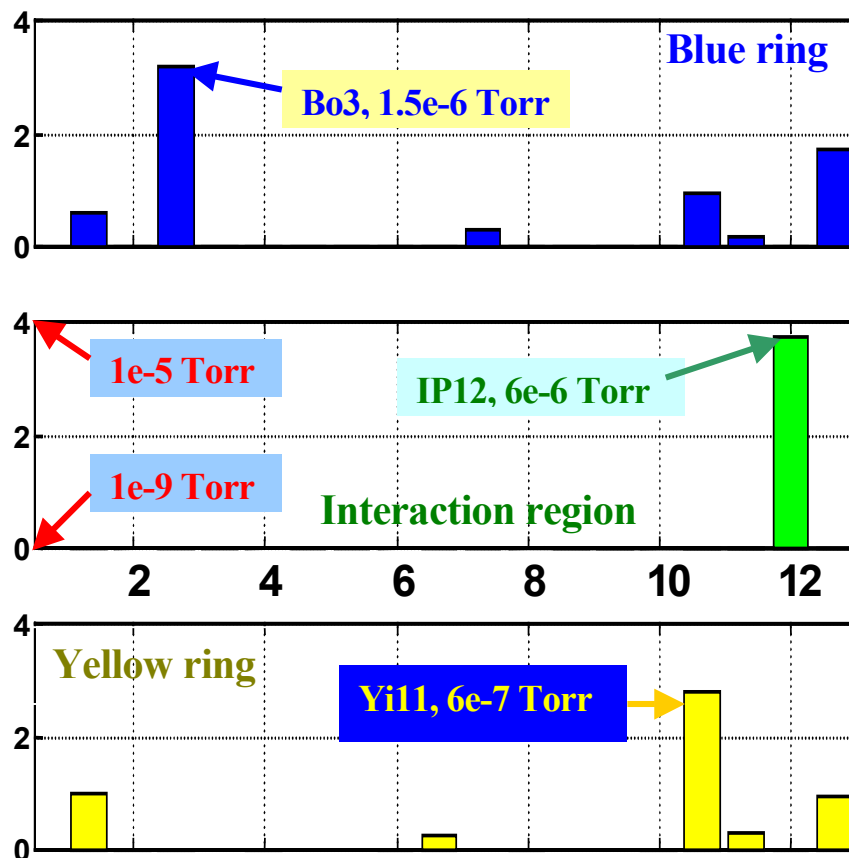
- In 1999, N. Hilleret et. al. proposed LHC beam scrubbing -  $1\text{mC/mm}^2$  may reduce SEY from 2.2 to 1.2, memory is long.
- This large dose in a reasonable time period is always accompanied by very high pressure rise.
- Unfortunately, almost all machines having EC problem, e.g. PSR, SPS, and PEP-II, the instability and/or emittance growth comes before the high pressure rise. Modest pressure rise,  $\sim 10^{-7}$  Torr, contributed little in scrubbing.
- SPS decided to have a scrubbing run of 10 days in April, 2002. LHC required beam was achieved in first time.

	Pressure rise	Dose / 24 hrs	Scrubbing effect / 24 hrs
PSR	$1 \times 10^{-7}$	0.012	Modest instability threshold increase
SPS 2000	$7 \times 10^{-7}$	0.064	Pressure rise reduced by factor of 5
SPS 2002	$5 \times 10^{-6}$	0.5	Pressure rise reduced by factor of 100
Unit	Torr	$\text{mC/mm}^2$	

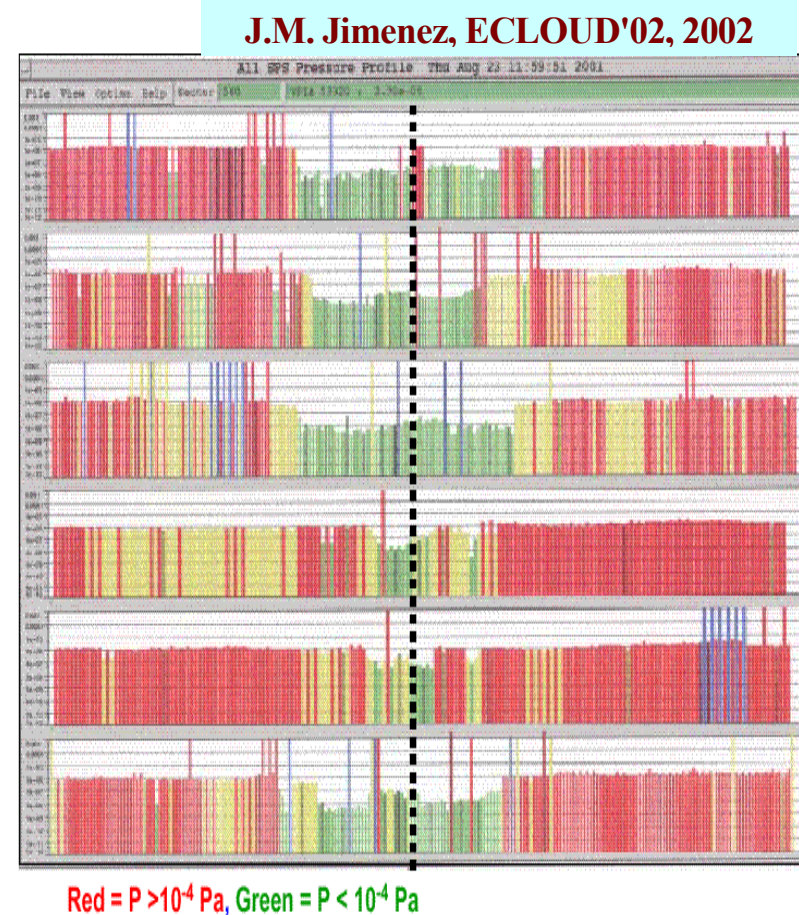
Table 1: Comparison of pressure rise, dose, and scrubbing effect

## 2. RHIC scrubbing

- In the RHIC, vacuum valve closed before the strong instability showed up, may because of that the EC only takes place in part of the warm sections, not the whole ring.
- The problem for RHIC scrubbing is that pressure rise is very unevenly distributed.



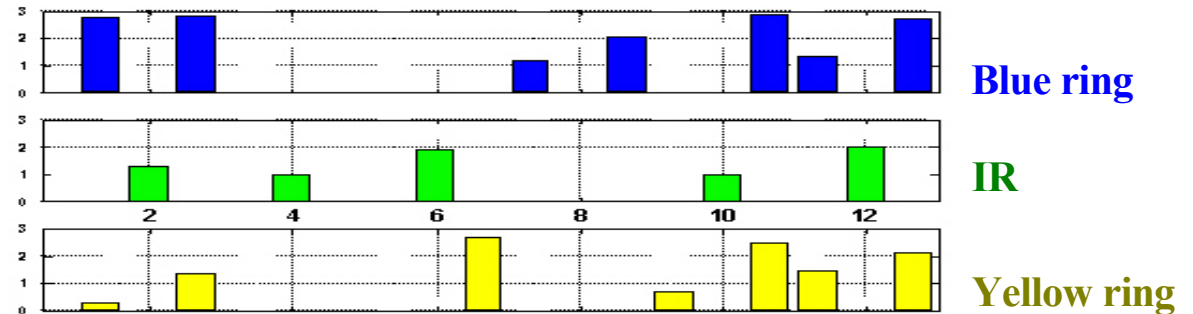
RHIC pressure rise of Gold fill 1797



SPS pressure rise distribution

## Proton beam

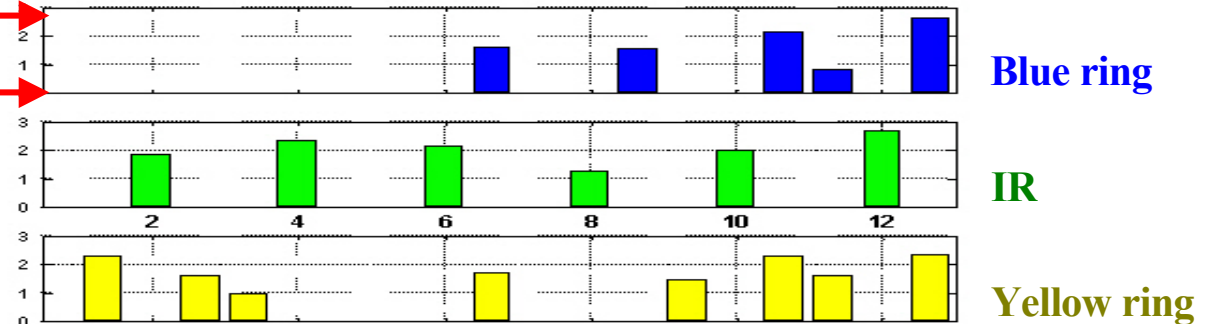
Proton fill 2237  
110-bunch, 1/16/02



1e-6 Torr

1e-9 Torr

Proton fill 2189  
55-bunch, 1/10/02



### 3. Preliminary plan

- 2-4 hours in early d-Au run for testing.
- Using 110-bh gold (or deuteron) beam to reach the pressure rise of **5e-6 Torr**.  
Observe pressure rise at highest pressure spots. Once the pressure reduced, dump the beam and inject a higher intensity beam.
- Keeping the highest pressure, a factor of 100 pressure reduction in 12 hours is expected.